Remote Safety Distance Control for Motor Vehicles

Roberto P. L. Caporali

***Abstract:** We define a method for monitoring and controlling the Safety Distance between motor vehicles. Failure to respect the safety distance between cars on roads and especially on motorways (where speeds have high values) is among the main causes of accidents. This fact generates serious inconveniences such as roadblocks, with enormous delays for car drivers reaching their destinations, as well as possible deaths and injuries. At the current state of the art, in this regard, steps have only been taken to define auxiliary systems on vehicles that signal when this distance has been reached, advising the driver to reduce speed to restore the minimum safety distance. But such systems are, in practice, negatively considered by motorists and do not lead to positive results. The Method and System defined in this work instead involve the use of a Remote System for controlling the Safety Distance, of the same type as those applied for speed control on roads and motorways. These systems are hated by car drivers, precisely because of their effectiveness and deterrence. In this work, first of all, the state of the art regarding Safety Distance control systems, which up to now have only been present on cars, is analyzed. The different methods of calculating the Safety Distance between vehicles are subsequently described. The method defined in this work is then presented, based on the remote detection of the Safety Distance on roads, especially at high speed, describing it with some figures. Here, we highlight the innovation of the system presented in this work, where, for the first time, a System for Remote controlling the Safety Distance is considered.*

***Keywords:** Safety Distance, Remote Control, Infringements Detection.*

I. INTRODUCTION

The problem of failure to respect safety distance arises from the enormous number of accidents that occur on roads and, especially, on the motorways due to failure to maintain these distances. The consequence of this is the long queues on motorways that, often, do not allow rapid connections between the various industrial parts of a country and which, for the vast majority, are due to accidents caused by failure to comply with this rule. That generates serious economic damage in the different countries in which it occurs, due to the delay that accumulates in motorway queues. Without forgetting the inconvenience and problems for individuals in the queue, as well as the possible physical consequences of accidents. Two main objections are made to the use of a Safety Distance Control.

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The first objection is given by the fact that the population sees traffic control systems (such as speed cameras) essentially as methods used by the State or Local Authorities to indirectly tax the population and, therefore, as a limitation of freedom. To this objection, we must reply that this control is carried out specifically for the population, to drastically reduce accidents. Even because its maximum usefulness and, therefore, its maximum use should be implemented on motorways, and not on internal roads within city municipalities.

The second objection lies in the fact that the Safety Distance is the consequence of a mathematical expression, and, in any case, is not a predefined value. It, as will be seen in this paper, can be calculated in different ways, therefore without uniqueness. This lack of unambiguity could generate protests from the population affected by the controls. However, if we consider only the cases where the speed of the cars reaches high values (let's assume higher than 80-100 km/h), the corresponding Safety Distance is, whatever the calculation method used, higher than a few tens of meters. Therefore, when distances between two successive vehicles are detected that are less than, for example, five meters (which happens very often on the motorway, due to the incorrect behavior of many car drivers), no one could object to the dangerousness and therefore the punish ability of a situation thus generated.

In recent years, some works have been produced regarding the possibility of calculating the Safety Distance on a computer present on the vehicle, having as input some sensors present on the vehicle, to send the driver an input suitable for reducing the speed and, therefore, the distance with the vehicle in front. For this purpose we can cite the papers [1]-[2]-[3]-[4]-[5]-[6]-[7]-[8]-[9]-[10]-[11] -[12-[13], as well as the recent Patents [14]-[15][22][23][24]. In particular, papers [1]-[2]-[3]-[4]-[5]-[6] concern new calculation methods to define the Safety distance. However, all these systems focus on either defining the best method for calculating the safety distance or defining the optimal system for receiving the input data and transmitting it to the vehicle's sensors. The fundamental flaw that, in our opinion, this type of approach has is that it completely ignores the unwillingness of vehicle drivers to really achieve the safety distance. Believing that a driver, who on the motorway approaches the rear of the previous car at high speed to "push" it into moving lanes, will follow this type of input is, to say the least, naive. Unfortunately, a high percentage of car drivers have this habit, especially on European roads and motorways.

Therefore, only an external detection system, which is connected to a traffic control and police station, could be an effective deterrent to such very dangerous habits. This will significantly reduce the percentage of accidents that occur.

With this aim of reducing accidents, in the past works and patents related to the detection of excessive speed, the so-called "speed cameras", had been developed. In particular, we refer to the Patents [16]-[17]-[18]-[19], which concern methods and systems for monitoring and controlling the speed or the average speed of vehicles in transit. Instead, the work presented in this paper intends to respond to the problem of the enormous number of accidents caused by the excessive proximity of cars, especially at high speeds. This work is based on the definition of an innovative safety distance detection system.

In this paper, we propose a different and practical approach. We develop a system and method for remote detection of Safety Distance. Starting from the experiences we have had in work relating to the so-called "speed cameras", we develop a system using sensors to detect the passage of vehicles and, therefore, calculate the distance between two successive vehicles.

The advantageous novelty of this method is given by the fact that, for the first time, it is considered a System for Remote controlling the Safety Distance, thus allowing effective detection of infringements.

We organized this work in the following way. In Section II, the Methods for the calculation of the Safety Distance are represented. In particular, possible variations due to the weather are highlighted. In Section III, a description and an implementation of the method are presented using some significant figures. We highlight, in particular, the uniqueness of the solution presented. At the end, in Section IV concluding remarks and developments are defined.

II. SAFETY DISTANCE: CALCULATION METHODS

The safety distance is the distance that a vehicle must maintain compared to the one in front of it, to be able to stop in time, when and where necessary, without hitting the vehicle in front of it, if the latter stops abruptly. What must be taken into consideration to calculate the minimum safety distance between two vehicles? Various factors, including the physical state, quick reflexes, and age of the driver; physical characteristics of the vehicle; road section you are traveling on; weather conditions; visibility; road slope; traffic; condition of the tires and the vehicle in general (brakes, suspensions, etc.); conditions of the road surface. The calculation of the minimum safety distance should take into consideration the distance traveled by the vehicle in front of us in one second. That is to understand how much time/distance is needed between the possible activation of the stop sign and the braking of your vehicle, therefore assuming that the vehicle in front has the same braking distance as ours. In any case, it is clear that the minimum safety distance increases as the speed increases.

But that's not enough: the parameters we listed above must be taken into consideration. In fact, as the speed increases, a quadruple braking distance will be needed. A very simple calculation method, used in the past, provides D = (V/10)*2, where “D” represents the safety distance, and “V” is the speed at which you are traveling. However, even this empirical method does not take into account all the variables listed above. Another empirical method provided that it can be performed without distractions and in conditions of total safety, is to take a reference and start counting from when the vehicle in front passes it to when we catch up with it. This time should never be less than 3 seconds but may increase under certain conditions. Another useful calculation that can be made concerns the speed at which we are traveling: if we travel at a speed of 130 km/h, for example, it means that we are traveling at 36 m/s. If we think back to the 3-second method, it means that the minimum distance must be at least 108 meters, but we also said that in certain conditions this space must be increased. On average, the reaction time of an individual in good psychophysical conditions is approximately 1 second or half of a range that varies between half a second and 1 and a half seconds. In this situation, the action of moving the foot from the accelerator to the brake takes approximately 0.8-1 seconds, a time interval in which we will have traveled about twenty meters (if we travel between 50 and 80 kilometers per hour, at speed stronger, this space also increases). The reaction time, and the distance covered during this period, must always be related to the speed.

It is obvious that a car with worn tires or with a braking system that has not been checked recently, or even with a certain type of load on board, will need larger stopping distances. Therefore, the answers given by the reaction time can change, because in the aforementioned case, we considered not only a guy in good psycho-physical conditions but also a vehicle that has always enjoyed good maintenance and which does not present particular problems.

Furthermore, in the stopping distance, we must also take into account that of the vehicle in front of us, thus implying other factors to think about. For example, if, for the reasons just mentioned, our stopping distance is quantified as 40 meters and the stopping distance of the previous vehicle is 30 meters, this imbalance will inevitably lead to a different braking time. Moreover, if the safety distance minimum is not respected or it is in any case lower than expected, then the risk of a rear-end collision will be very high. Therefore, it can be said that the safety distance is the result of the sum of the distance traveled in the reaction time and the braking distance based on the speed at which you are traveling and other factors. The formula to calculate the braking distance is as follows: V2/(2a·μ) where “V” is the velocity (expressed in m/s), “a” represents the average deceleration of 9.8 m/s^2 (i.e. the gravitational acceleration term) and “μ” the coefficient of dynamic friction between tires and road surface. The latter varies according to the conditions of the asphalt: starting from 0.8 in the case of dry asphalt, to 0.05 in the case of an icy road, passing through 0.4 in the case of a wet road).

In case of rain, the safety distance values can increase by 20-30%, depending on the amount of rain. When it rains, you should moderate your speed, lowering the expected limit by at least 20 km/h. If it rains, you must carefully consider the variable factors that affect the vehicle's braking distance.

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In recent years, some recent works have highlighted some innovative methods for calculating the Safety Distance. In particular, the work of Lian et al. [2] presents a new safety distance model to make vehicles adapt to different driving roads with an adhesive coefficient between tire and road and to conform to drivers' characteristics with a driving intention parameter. The work of Chen et al. [1][20][21] derives a new safety distance model. The system detects the distance between the car and the in front of vehicles (obstacles) and uses the vehicle speed and other parameters to calculate the braking safety distance of the moving car. The system compares the obstacle distance and braking safety distance which are used to determine whether the moving vehicle's safety distance is enough or not.

In our work, however, the method of calculating the safety distance is not fundamental, since our work is based on a method to reduce violations of the law, recording the violation states due to successive cars that are too close together. Therefore, our method does not require a formula for defining the Safety Distance. Simply, a "Small" Distance is assumed, certainly lower, once the speed is fixed, then the Safety Distance, however it is calculated. For example, at 100 km/h, a distance of 6 m is certainly and significantly less than any logically calculated Safety Distance. However, as proof that this detection could serve as a useful deterrent, many cars can be seen on the motorways traveling at high speed very close ("glued") to the car in front, with enormous risks of a possible accident.

III. METHOD AND SYSTEM FOR EXTERNAL CONTROLLING OF THE SAFETY DISTANCE

An object of the present work is to provide a system for detecting the distance between two successive cars. Another object of the present work is to define a system for detecting the speed of motor vehicles and a way that allows sending the detected data directly to authorities in charge of controlling highway code infringements.

The system developed to control the Safety Distance of vehicles on motorways comprises at least one infrared ray or equivalent electronic system designed to illuminate vehicles in transit and at least one camera black/white or color - capable of detecting the rear image. Photocell speed detection systems are the most widespread. They usually have two laser photocells: the passage of a vehicle's head through the beam of the first photocell, interrupting it, starts the detection by starting a timer, while the passage through the second beam blocks the timer. Once the distance between the two cells is known, the speed is calculated as a function of the time taken to cross the two beams. If the detected speed exceeds the set value, the device takes a photograph of the vehicle, which in the models currently on the market is in digital format.

The system also provides a photoelectric sensor capable of detecting the moment in which a first vehicle passes under the sensor itself. Subsequently, it also determines the moment in which the next car passes. Together with the speed data obtained with the camera and with the sensors for detecting speed, this overall system can provide the necessary data to a local computer for calculating the distance between the two subsequent cars. Therefore, if the distance itself is less than the distance established by the relevant Authority as the Safety Distance, an infringement will be detected. A large but reasonable margin of error will be taken into account for the measurements themselves, so as not to be able to encounter any complaints in any way. If the distance detected is, for example, 5 m, a measurement error of 50% can easily be added, but the distance between the cars will always be significantly lower (at high speed, let's say above 100 km/h). at any Safety Distance, however, it is calculated. Therefore, it will be a distance with a "high risk of accidents".

The system also provides a computer able to process, transmit, and receive the signals of the video camera; the computer stores at least temporarily images and other data of the vehicles in transit and calculates the speed of the vehicle. Besides, we will have a remote station able to receive images and other identification data of specific vehicles from the local stations. We can provide various transmission systems (GSM, mobile phones in general, optical fibers, or similar) to communicate between the various local stations and the remote station. Using this arrangement, the remote station receives data relating only to the vehicles to which an infringement shall be contested. Eventually, inside the column, there are sensors designed to identify and detect a possible action of vandalism.

The Method and System defined in this work to define a Remote Safety Distance Control is represented, and it is made more evident through the following figures.

Regarding Fig.1, the system comprises at least one vehicle detection unit 8, which can detect the type and speed of the vehicles, in combination with one video camera 1, which can read the license plates of the vehicles. The vehicle detection unit 8 is conveniently constituted for example by an electronic detector 5, which is connected to a sensor. The camera is installed on a pylon 2. The sensor is constituted for example by two plates 7 installed in the paving of the lane to be monitored. Said unit 8 therefore performs continuous monitoring of the motion of vehicles and transmits information to the local or peripheral processing units. Video camera 1 allows to capture of the images of the vehicle in transit to detect the license plate of the vehicle.

Correspondingly, to obtain the distance between the 2 subsequent vehicles, concerning Fig.2, a detection 4 of the passage of the first vehicle 1 is carried out, via a photoelectric sensor. Concerning Fig.3, once vehicle 2 has arrived, detection 4 is in turn carried out at the moment in which the second vehicle passes. The distance between the two vehicles is then calculated based on the speed detected by sensor beams 5 and 6 in Fig.1. If the calculated distance is less than the established safety limit distance, the photograph of the license plate of vehicle 2 detected with camera 3 of Fig. 2 and Fig. 3 is sent to the judicial authority.

An infrared light source is associated with the video camera 1 to be able to detect the license plate even in low-visibility conditions or at night. Video camera 1 can be installed on one of the portals 2 normally installed on highways. Substantially, the video camera acquires images of all the vehicles in transit in the monitored lanes, regardless of their speed.

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The system must therefore store the data of the images related to the transits, which will be deleted if no infringement has occurred.

The functions that the software of the central processing unit must process are a) detection of infringements by processing the data received from the peripheral units; b) verification of infringements; c) Transmission of the data related to the infringement to the information system of the highway police.

We can summarize the data flow relating to Safety Distance detection, referring to Fig.4. In this figure, a flowchart of the method for verifying the infringement of the Safety Distance is represented. First, the vehicle speed is acquired, as described above. At the same time, the passages under the photoelectric sensors of the first and second vehicles are acquired. In this way, using the data defined above, the distance between the two vehicles can be calculated. At this point, we can decide whether the calculated distance is less than the established Safety Distance. If it is less, the infringement is detected and the data is sent (as established above) to the relevant Authority.

An objection that could be made to this method is that it would detect many infringements in the event of queues forming, for example on motorways, when the speeds of the vehicles are very low and the distances between them are very small. However, it is clear that this method only makes sense to be applied when travel speeds are high, above a high threshold, for example, 100 km/h.

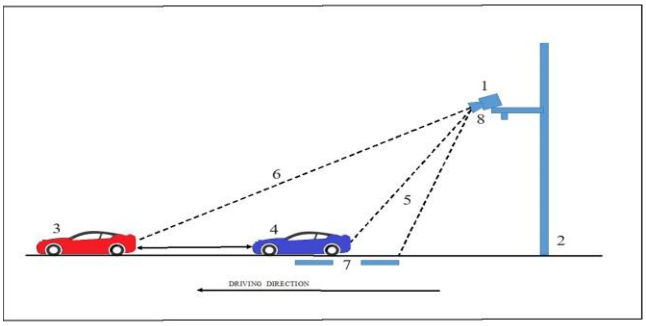

Fig. 1. Speed Control and License Plate Photography through Camera 1, Relating to the Passage of Vehicles 3 and 4

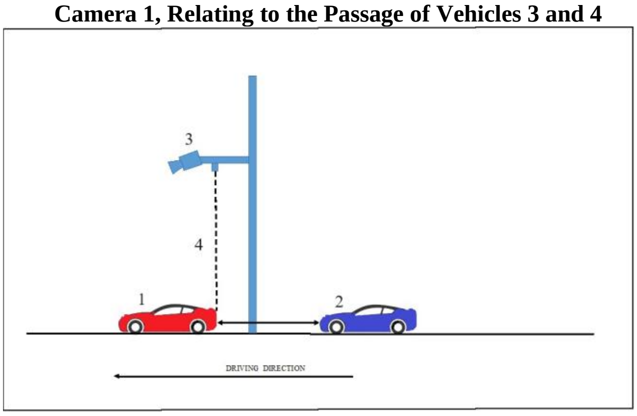

Fig. 2. Control of the Transit Position in Correspondence With Position Sensor 4, Concerning Vehicle 1, to Calculate the Distance Between the Vehicles

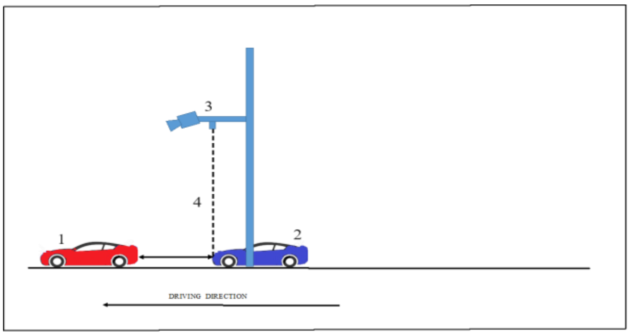

Fig. 3. Control of the Passage Position in Correspondence with the Position Sensor 4, Relative to Vehicle 2

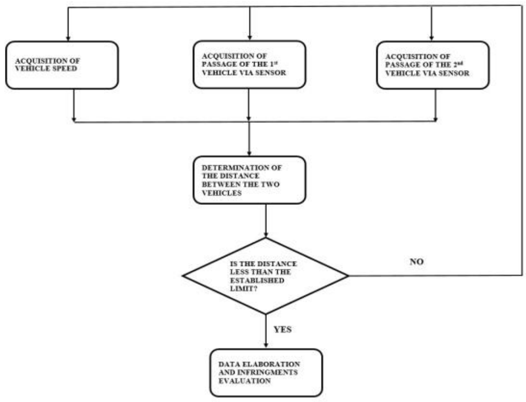

Fig. 4. A simplified Flowchart of the Method for Verifying the Infringement of the Safety Distance

IV. CONCLUSION

This work describes a method for monitoring and controlling the Safety Distance between motor vehicles. The method defined in this work involves the use of a Remote System for controlling the Safety Distance, of the same type as those applied for speed control on roads and motorways. The different methods of calculating the Safety Distance between vehicles have been described. Subsequently, we presented the method developed in this work, based on the remote detection of the Safety Distance on roads, especially at high speed, describing it with some figures. We highlight that the innovation of the system presented in this work results in the fact that, for the first time, a System for Remote controlling the Safety Distance between motor vehicles is considered.

In the future, we could implement a method capable of combining the effect of the safety distance detected remotely and controlled by the Authority, with the direct control of vehicle driving. For example, the transmitter could be composed of an interface, which in turn is connected to a transmitter that sends the signal using a suitable transducer. The receiver will inform the driver of the presence in the proximity of a transmitter (Safety Distance control) using information either in the receiver display or in the display inserted in the dashboard of the vehicle. On the display will be displayed the actual Distance with the previous vehicle. The receiver could be combined with the speed regulator (Cruise control) installed on vehicles by the manufacturer.

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Authors Contributions	I am only the sole author of the article.

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